

CONDITIONS FOR TURBINE OPERATION CONDENSING TURBINE SST900 – IP620B	Respons. dept	Orig. date	Reg.
	RSC	2011-06-14	BB000013
Prepared		GREC Gainesville	
Oskar Mazur			

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1. GENERAL

- These values shall be used for this specific turbine unit together with the general start up and operation instructions given in the TURBINE MANUAL
- The full set of values for alarm, trip or limitation is to be found in the document “Setting list”.
- More details about the instrumentation can be found in the document “Additional Settings for Turbine Protection” (1CS109363).
- IP refers to the medium pressure turbine (SST900-IP620B).
- Terms and definitions refer to IEC 45-1.
- Steam quality is specified in STI 0700-01E.

a Initial conditions IP turbine, upstream ESV

- Initial pressure

Rated	109.63 bara/	1590 psia/
Normal	109.63 bara/	1590 psia/
- Initial temperature

Rated	537.8 °C	1000.0 °F
Normal	537.8 °C	1000.0 °F

b Exhaust conditions, IP turbine

- Exhaust (condenser) pressure

Normal	0.085 bara/	1.23 psia/	2.51 "HgA
Alarm high	0.18 bara/	2.61 psia/	5.32 "HgA
Trip high	0.25 bara/	3.63 psia/	7.38 "HgA
- Exhaust temperature at blade row L-0

Normal	42.6 °C	108.7 °F
Alarm high (max 1.0 h operation)	85.0 °C	185.0 °F
Automatic shut down	105.0 °C	221.0 °F
- Exhaust temperature at blade row L-1

Normal	71.0 °C	159.8 °F
Alarm high (max 1.0 h operation)	180.0 °C	356.0 °F
Automatic shut down	200.0 °C	392.0 °F

c Operating area IP turbine inlet conditions

- Area for pressure and temperature at turbine inlet is summarised in a diagram, see section 2. OPERATING AREA.

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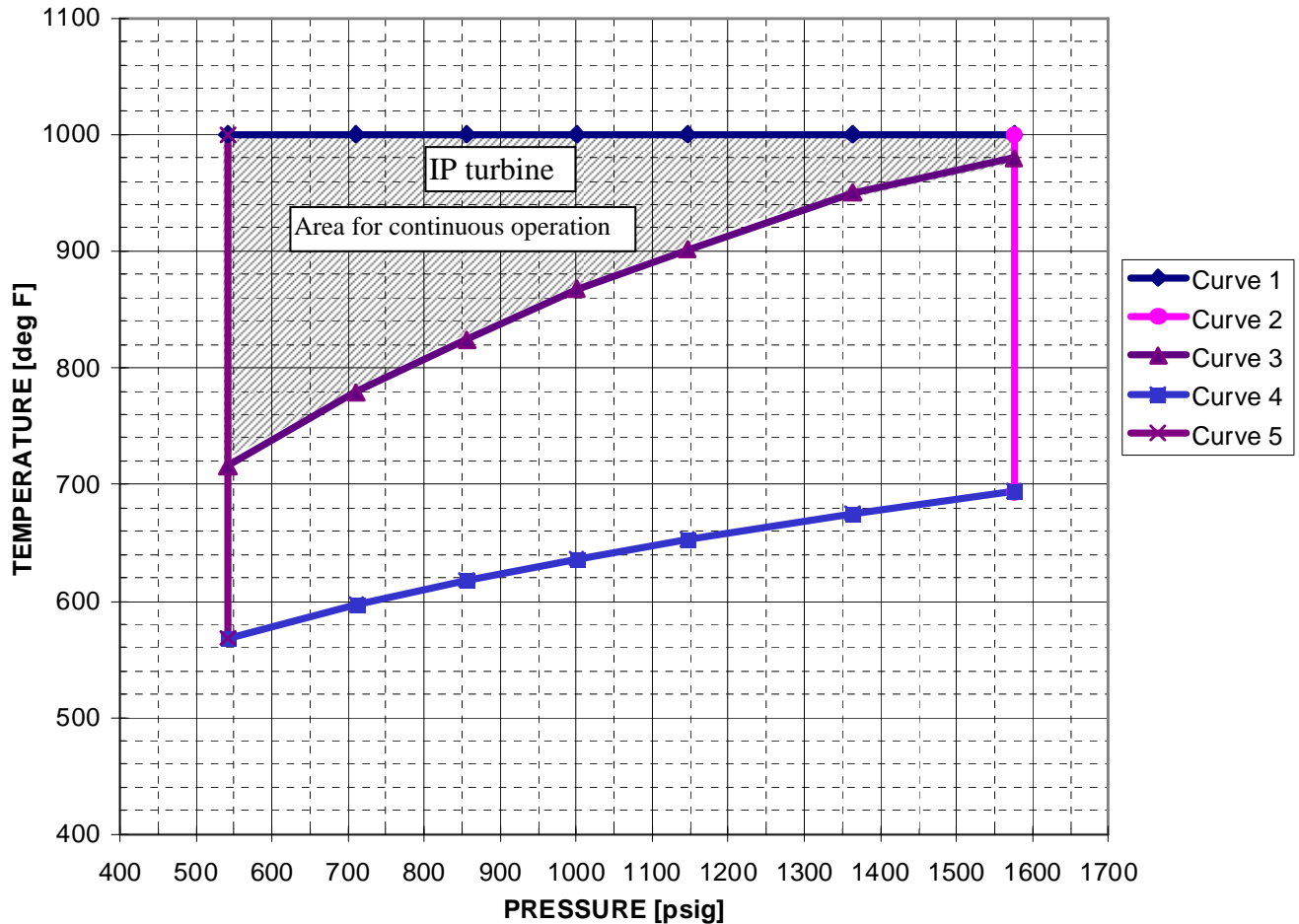
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2. OPERATING AREA

a Admission condition before ESV (IP-turbine)

- Curve 1:** Rated temperature IP turbine inlet
- Curve 2:** Rated pressure IP turbine inlet
- Curve 3:** IP turbine exhaust moisture limitation (VWO)
- Curve 4:** Start-up limit 50 °C (90 °F) superheat
- Curve 5:** Start-up limit low boiler pressure

OPERATING AREA



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3. LIMITS OF VARIATION OF RATED CONDITIONS

a Initial pressure

The average initial pressure at the turbine inlet over any 12 months of operation shall not exceed the rated pressure. In maintaining this average, the pressure shall not exceed 105% of the rated pressure. Further accidental swings not exceeding 120% of the rated pressure are permitted, provided that the aggregate duration of such swings over any 12 months of operation does not exceed 12 h.

b Initial temperature

The average steam temperature at any inlet to the turbine over any 12 months of operation shall not exceed the rated temperature. In maintaining this average, the temperature shall not normally exceed the rated temperature by more than 8 K (15°F). If, exceptionally, the temperature exceeds the rated temperature by more than 8 K (15°F), the instantaneous value of the temperature may vary between this figure and a value of 14 K (25°F) in excess of the rated temperature, provided that the total operating time between these two limits does not exceed 400 h during any 12 months operating period. Operating between limits of 14 K (25°F) and 28 K (50°F) in excess of rated temperature may be permitted, for brief swings of 15 min or less, provided that the total operating time between these two limits does not exceed 80 h during any 12 months operating period. In no case shall the temperature exceed the rated temperature by more than 28 K (50°F).

c Comments to initial pressure and temperature

This section only deals with how much pressure and temperature can exceed the rated conditions to fulfil design data for the pressure vessel and the hot components. The 12 months average not exceeding the rated pressure and temperature does not mean that the average must be kept. It is allowed to have 12 months average values falling below the rated conditions.

d Steam supply through two or more parallel pipes

Should steam be supplied to any terminal point on the turbine through two or more parallel pipes, the steam temperature in any of these pipes should not differ from that in any other by more than 17°K (31°F), except that during fluctuations not exceeding 15 minutes in duration within any four hour period, a temperature difference not exceeding 28°K (50°F) shall be admissible. The steam temperature in the hottest pipe shall not exceed the limits given in the preceding paragraph.

e Related Alarm and Trip levels for turbine protection

High temperature alarm:	$T_{s,rated} + 8K$
High temperature alarm (trip after 15 minutes):	$T_{s,rated} + 14K$
High temperature trip:	$T_{s,rated} + 28 K$

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4. RATE OF VARIATION OF ADMISSION CONDITIONS

Inlet temperature variation shall be within following limits. The alarm and trip values for the temperature rate of variation are set by the deviation of the actual admission steam temperature from a calculated ramp temperature as defined below.

Table: Temperature gradient limits and alarm/trip set values

	Initial steam temperature (IP turbine inlet)	
	increase	decrease
Allowed ramp per minute (R)	+3K (+5.4F)	-3K (-5.4°F)
Allowed step, momentary max 1 step/hour	+50K (+90°F)	-50K (-90°F)
Alarm	+35K (+63°F)	-35K (-63°F)
Trip	+50K (+90°F)	-50K (-90°F)

The alarm and trip values for the temperature gradient supervision are defined as the deviation (Dev) of the actual admission steam temperature from the ramp temperature T_{ramp} , calculated with the allowed temperature ramp per minute (**R**) as follows:

$$T_{ramp} = T_0 + R \times t ; \text{ where the time } t \text{ is counted from the beginning of the temperature change.}$$

$$Dev = T_{actual} - T_{ramp}$$

T_0 is the actual temperature at beginning of the temperature increase/decrease, if the deviation of an earlier temperature increase/decrease in the same direction is balanced. The deviation is balanced as soon as the actual temperature is equal to the ramp temperature T_{ramp} . If the deviation is not balanced T_{ramp} is continued from the previous temperature change in the same direction (T_0 and t are not reset). Consequently, the deviation persists in that case so that a short change in direction of the temperature variation can not reset the actual alarm and trip margins.

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5. OUTPUT LIMITATIONS

- Max. total generator output: **116.100 MW**
- Supervision of cooling flow needed for the IP turbine is done by pressure drop measurement.
- Minimum continuous load: **12.60 MW** at a condenser pressure not higher than 0.085 bara (1.23 psia, 2.51 inHgA) and steam admission conditions to IP-turbine 537.8°C (1 000°F) and 109.63 bara (1 590 psia). The minimum load is dependent on mass flow through the last stage of the turbine and limited according to a curve shown in document “Additional Settings for Turbine Protection”.

Lower load is permitted during start-up, provided that it is limited to maximum one (1) hour and the exhaust temperature is below its maximum allowed value (see section 1c).

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6. ADMISSION STEAM PIPE HEATING REQUIREMENTS

Prior to turbine start-up the turbine admission steam pipe must be heated.

A heating line of sufficient size shall be connected as close as possible to the inlet valve of the turbine (recommendation to meet temperature requirements in 7c).

A drain is required upstream the valve at the IP turbine.

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7. START UP CONDITIONS

a Turning gear

- Minimum inlet oil temperature for start of gear 15°C / 59°F.
- If not in operation, start turning gear at least 2 hours before running up.
- Do not stop turning gear until IP- turbine metal temperature is below 120°C / 248°F (about 120 hours after turbine shutdown).

b Gland steam conditions

Normal gland steam supply

- Temperature: 259.0 to 537.8°C/ 498.2 to 1000.0 °F, not lower than 200°C (360°F) below the highest measured turbine casing metal temperature.
- Pressure upstream gland steam valve: 32.9 to 109.6 bara/ 477.2 to 1590.0 psia
- Min. superheat: 20°C/ 36°F in the supply line, 50°C/ 90°F recommended.

c Steam conditions, turbine initial steam inlet

- Minimum temperature upstream the IP-turbine shall guarantee dry steam. This is depending on pressure but can be expressed as minimum superheat.
Minimum superheat: 50°C / 90°F
- Steam temperature at IP-turbine initial steam inlet shall not be lower than 50°C / 90°F below metal temperature at IP-turbine casing inlet.
- Maximum steam temperature during cold and warm start-up, see the corresponding start-up diagram.
- Steam pressure upstream turbine, see the start-up diagrams and OPERATING AREA.
- To follow the loading sequence curves in the diagrams for START UP a minimum boiler flow capacity of 10% - 15% is necessary before running up.

d Condenser pressure

To release the running up of the turbine the condenser pressure must be below 0.25 bara (3.63 psia/7.4 inHgA), see also section 9c “By-pass operation”. When initiating turbine run-up the condenser pressure should be below 0.18 bara (2.61 psia / 5.3 inHgA) to avoid alarm due to high condenser pressure.

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8. START UP

a Start-up categories

The start-up categories are defined by the metal temperature **T_m** measured at the IP-turbine just before run-up begins:

Start mode	T_m_{SST900}
Cold start	< 220°C/ 428°F
Warm start	220°C/ 428°F – 420°C/ 788°F
Hot start	> 420°C/ 788°F

The inlet conditions temperature and pressure at the turbine inlet are significantly reduced during cold, warm and hot starts as shown in the start diagrams.

b Running up sequence

Running up is guided by the start-up categories and shown as **n/no** curve in the below graphs. Run-up is not allowed until **T_s** is greater than **T_m-50°C (T_m-90°F)** (use turbine by-pass to raise T_s). Delay in running up may show up due to low oil inlet temperature or high vibration level. Time for synchronization is not included in the start-up graphs.

c Loading sequence

Loading times after running up and synchronizing are shown as N1 to N6 curves in the following graphs. Loading is guided by the metal temperature **T_m_{SST900}**. Additional conditions to the enclosed start-up curves:

- T_m = Metal temperature measured in turbine casing before run-up.
- T_{s, high} = Max. steam temperature measured in the main steam line upstream the turbine
- T_{s, low} = Min steam temperature measured in the main steam line upstream the turbine.
NB! The highest of the minimum temperature shown in the start-up diagram and the temperature defined acc. to section b above defines the minimum allowed steam temperature for start-up.
- P_{s-high} = Max. steam pressure measured in the main steam line upstream the turbine
- P_{s-low} = Min steam pressure measured in the main steam line upstream the turbine
- N = Percentage of maximum total generator output (*see section 5. Output limitations*)
- n/n₀ = Actual speed / Synchronous speed

Minimum continuous load, see section 5, “Output Limitations”.

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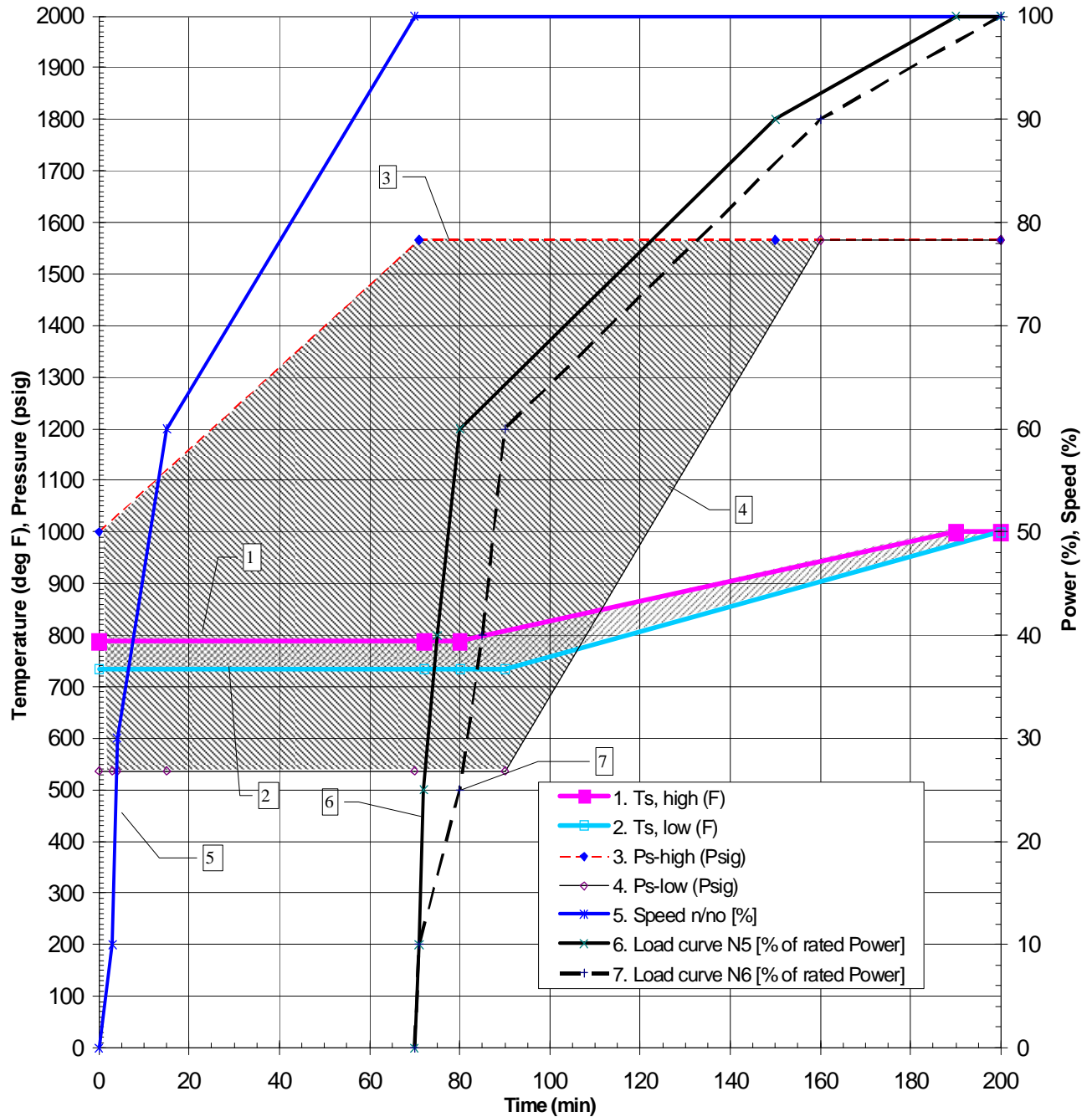
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Cold start

Curve N6: $T_{mSST900}$ less than $130^{\circ}\text{C} / 266^{\circ}\text{F}$
Curve N5: $T_{mSST900}$ less than $220^{\circ}\text{C} / 428^{\circ}\text{F}$

Cold Start GREC Gainesville



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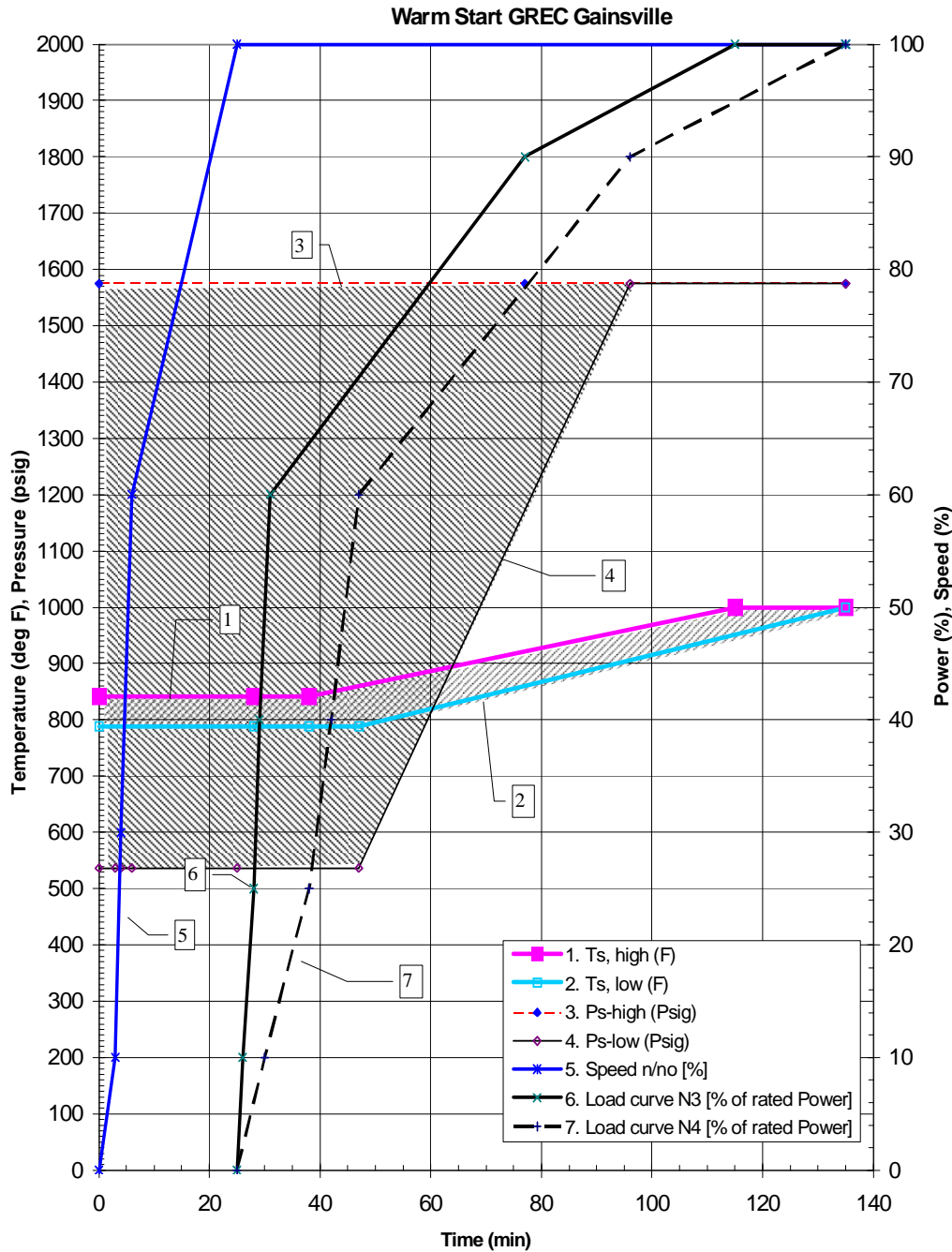
Warm start

Curve N4: $T_{mSST900}$ less than $330^{\circ}\text{C} / 626^{\circ}\text{F}$

Curve N3: $T_{mSST900}$ less than $420^{\circ}\text{C} / 788^{\circ}\text{F}$

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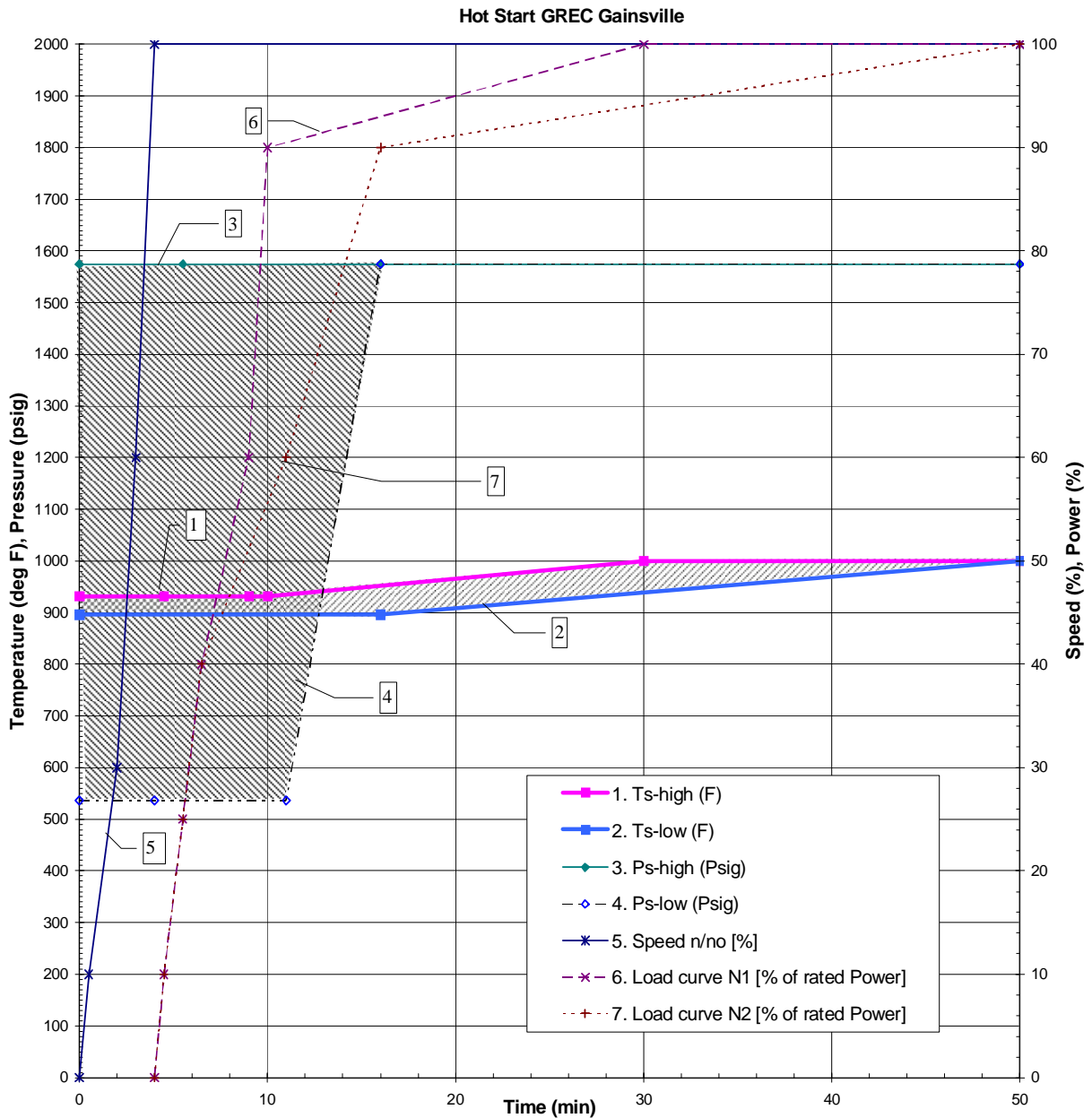
Hot start

Curve N2: $T_{mSST900}$ more than 420°C / 788°F

Curve N1: Restart within 30 minutes and $T_{mSST900}$ more than 420°C / 788°F

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9. BY-PASS OPERATION

a General

When the by-pass is in operation there are some requirements which have to be fulfilled for protection of the steam turbine.

- The lubricating oil system shall be in operation..
- The sealing steam system and the leak off steam system shall be in operation.
- The turning gear shall be in operation.

For bypass operation with turbine operation the same requirements as for normal steam turbine operation are valid.

b Temperature

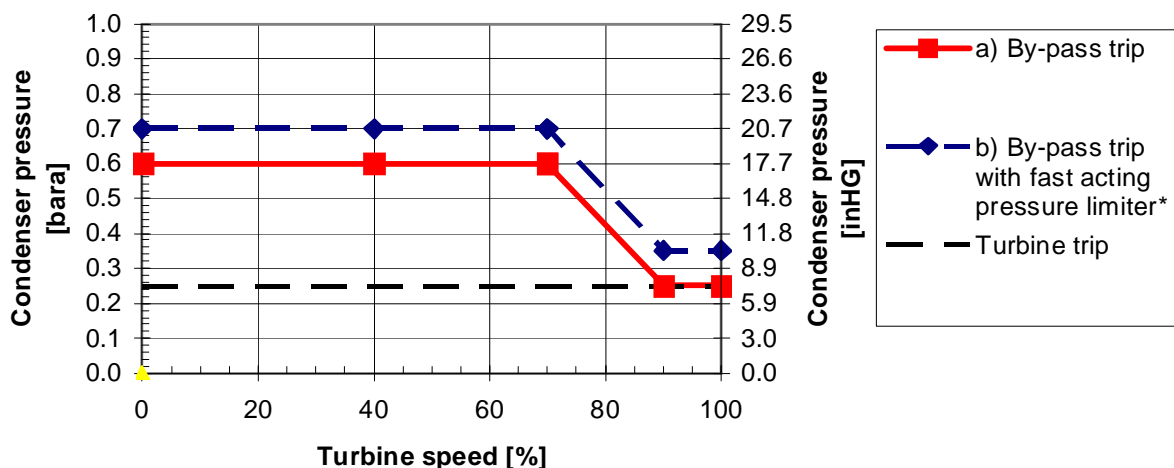
The temperature requirements in the turbine exhaust are the same as for normal turbine operation.

c Pressure

The turbine sets the following limits for the by-pass operation. See diagram below.

At start-up when condenser pressure is less than 0.5 bara (14.7 inHgA) the by-pass system is released. Before run-up of the turbine is initiated the condenser pressure must be below the trip limit given in 1b, “Exhaust conditions IP turbine”.

Allowable Condenser Pressure for By-pass Operation



*It is allowed to rise the bypass trip set value as indicated in the graph if the by-pass is equipped with a (fast acting) condenser maximum pressure limiter. The controller and the bypass equipment shall be fast enough to maintain the condenser pressure at the set value even during disturbances (at varying condenser load, etc.). The controller/bypass station shall be able to maintain the condenser pressure within +/- 0.05 bar from the set value. The maximum allowed set value is 0.1 bar below the bypass trip limit and hence identical with curve a) in the graph.

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10. VACUUM BREAKING REQUIREMENTS

The vacuum breaking system has the following tasks.

- Vacuum breaking is allowed when the turbine speed is less than 10% of rated turbine speed.
- Full breaking of the vacuum shall be initiated at loss of gland steam supply when the turbine speed is less than 10% of rated turbine speed.
- Emergency vacuum breaking. The purpose of this procedure is to decelerate the rotor shaft down in the shortest possible time. When the vacuum breaking valve is opened, air flows into the condenser and turbine.

The resulting rapid rise in pressure has a powerful braking effect on the turbine shaft ensuring that the critical speed zones are passed through as quick as possible.

Vacuum breaking at steam turbine speed above 10% of rated speed may only be initiated in an absolute emergency (e.g. extremely high vibrations) by the operator manually activating the vacuum breaker. At the same time as the vacuum breaking is initiated a steam turbine trip is made.

Automatic emergency vacuum breaking is made in case of durable high high vibrations, on turbine or generator.

High-high condensate level in a low-pressure preheater not equipped with a check valve will automatically initiate vacuum breaking to avoid water entering the turbine.

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